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AMERICA'S INFERIOR POSITION IN THE SCIENTIFIC WORLD.

BY CARL SNYDER.

IT cannot be said that America has produced no great men of science. It was the discoveries of Franklin that gave an impetus to the early study of electricity. The work of Benjamin Thompson, Count Rumford, was done chiefly in Europe; but he was born in Massachusetts. In a sense, Joseph Henry was the co-discoverer with Faraday of electrical induction, from which the dynamo and the greater part of our vast electrical industries have sprung. Cope, Leidy and Marsh were potent factors in establishing the truth of evolution. To whomsoever one may care to ascribe the discovery of anaesthesia—Morton, Wells or Long—they were all Americans. Draper was the first to photograph the stars. The calculations of Professor Newton, of Yale, first drew attention to the importance of meteorites; they may yet give us a clew to the origin of worlds.

The number of men of parts is to-day greater than ever; they are to be found in every field. Simon Newcomb is, with Lord Kelvin, the sole English-speaking associate of the French Academy. The achievements of Professor Willard Gibbs are better known in Europe than in our country; and the same is true of the mathematical work of G. W. Hill. Professor Langley's bolometer and the marvellous things he has done with it are a vital part of modern physics; the like may be said of the ingenious contrivances of Rowland and Michaelson. Such astronomers as Pickering, Burnham and Keeler put America in the front rank in astronomy. I might lengthily extend the list.

We have had, we have, men who have done genuine and distinguished work; the list is distinguished and worthy. Yet it is all too brief. Despite many notable figures, despite much notable achievement, America's position in the world of science is inferior. The count of our universities and colleges of the first rank outnumbers that of England or France two or three to one. Germany alone has more. The sums expended upon them are proportionately greater; Germany alone is as liberal as we. Even eliminating the recent outpouring of subscriptions, the endowments of our chief institutions of learning compare more than favorably with those of any other country, centuries older though they may be. Neither the state nor our rich men have been niggardly. Stephen Girard was born a century before Mr. Rockefeller. And the number of our students has always been large. We have lacked neither place, means nor material. Nor, it would appear, has the quality of gray matter been lacking. In the field of applied science, no other nation has a prouder record. We do not forget that it was Fulton who ran the first successful steamboat; that, had not Napoleon been possessed of a contemptuous stupidity, in refusing Fulton's offer, the Corsican might have invaded England and rewritten some pages of history. Morse may not have been the sole inventor of the electromagnetic telegraph; but if any one man is entitled to that honor, surely it is he. His system superseded all others. Graham Bell is a Scotchman, it is true; but he is a typical American "for a' that." All his work on the telephone, and his lesser known work with the phonograph, the radiophone and the like, were done in this country. His only competitor in the invention of the telephone was Elisha Gray, of pathetic memory. These are but instances from a crowd.

Why, then, has the United States so slight a share in the marvellous scientific advance of the century? Why, even in the face of a fine roll of names, can it be said with truth that our position is inferior? I shall try to illustrate.

Pasteur's memorable discovery that the fermentation of beer was due solely to the presence of minute organisms, microbes, was made early in the sixties. That was forty years ago. Step by step the ideas of Pasteur grew and broadened. Applied to the disease of the vines, then to dying silk worms, then to sheep cholera, they are estimated, before his death, to have saved to France alone a sum greater than the cost of the Prussian war, with the colossal indemnity demanded by Bismarck thrown in. Pasteur's own researches culminated in the germ theory of contagions. A young English surgeon, now Lord Lister, applied his idea to the method of surgical operations; this step was enormous. To-day, operations are common that were unheard of thirty or forty years ago; unknown diseases, such as appendicitis, have been discovered and a radical cure has been found for them. Germans, like Behring and Koch, Japanese, like Kitasato, a crowd of disciples and followers of the Master, as he is known in France, have extended Pasteur's ideas to the treatment of diphtheria, lockjaw, anthrax and many other scourges. Thanks to him, hydrophobia has been robbed of its terrors. At last, medicine begins dimly to emerge from quackery and empiricism, and bids fair in time to become a true science. All this belongs to the present day, most of it to the last decade or so, yet in all this brilliant list of discoveries and applications no American name is to be found, even though we have a larger number of medical schools, medical professors and medical students than any other country in the world.

In another field. To-day, ocean travellers, two hundred miles from land, talk with friends by a telegraph that crosses space with invisible feet. Marconi's admirable triumphs are merely the culmination of a long train of patient researches on the part of many workers in many lands. Clerk Maxwell, the English physicist, had predicted the common nature of electricity and light before our Civil War came to an end. Seeking to verify this surmise, Hertz, aided and advised by his patron, the veteran von Helmholtz, made his epochal discoveries at Carlsruhe. All the world knew of it thirteen years ago.

A host of experimenters were instantly in the field. The delicate coherer which made wireless telegraphy possible was the independent discovery of Professor Branly, of the Catholic University of Paris, and Professor Oliver Lodge, of Liverpool. Notable contributions have been made by the Italian Professor Righi, by the Germans, Professor Slaby, Count Arco, Professor Braun, by Professor Preece, of England, and Professor Bose, of Calcutta in India, to name but a few. It is to be noted that Marconi, like Morse, was an untrained amateur. It was a free field; no American entered. Not with all the stimulating examples of Edison, Tesla, Elihu Thompson was there one Yankee genius stirred to the task.

Another instance. We have become the first steel makers on earth. Every schoolboy knows the importance of the slightest admixtures in this industry; that one per cent. of carbon means one kind of steel; two per cent., another; four per cent., something wholly different. Within a few years the fantastic "art" of metallurgy has been transformed from a collection of housewives' receipts to a science. To-day we may make a gold that will melt in a candle flame, another that will cut glass. A mixture of metals, like lead, tin and bismuth which melt at three hundred to five hundred degrees, dissolves in boiling water. A scant trace of one substance introduced in another gives the latter unheard of qualities. Two metals like gold and iron, simply placed in contact, slowly interpenetrate and mix with each other, as if they were so much water and wine. An up-to-date, matter-of-fact text book of the science reads like the prescriptions of the old alchemists. Our ideas of the solid world about us have been irradiated with a new light.

I have before me the latest volume on metallurgy, even-handedly summing up twenty years of marvellous work. From almost a dictionary of names, Belgian, Netherlandish, German, English, French, Russian, I can find but two Americans, Professor Gibbs, whose contribution was most indirect, and Professor Howe. Not even a science upon which rests a billion-dollar trust seems to arouse the interest of one original, inventive American mind.

Mention of the old alchemists will recall to some readers the amazing results recently brought to view by Professor J. J. Thomson, of Cambridge University. Nowadays, every one has come to know a little at least of the high vacuum Crookes tubes, and the velvet glow that comes from them when the tubes are electrified, which gives rise to the Roentgen rays of familiar use. Sir William Crookes long ago showed that this glow is made up of streams of minute missiles. Bombarding a fluorescent screen, they produce the Roentgen light. Putting two and two and three and three together in the most ingenious way, Professor Thomson has been able to measure both the mass and speed of these flying particles, to count them, tell the measure of the electrical charge that each bears—a charge that is enormous. The Cambridge Professor has shown that these bits of matter are certainly a thousand times smaller than the smallest and lightest atom known to chemists; from whatever source they come, they are all alike, identical in every way. Is this primal matter at last? Is here the stuff from which all known substances are compounded? May we look forward to the time when we may build up any substance—gold for example—from the elements of any other? Have we realized the philosopher's stone?

However this may turn out, it is certain that these Cathode rays, or "corpuscles," as Professor Thomson calls them, are destined to play a leading part in all future conceptions alike of chemistry and physics. From their first recognition by a German, Hittorf, in 1868, there has been a long line of investigators, whose results fill bulky volumes. If, as now seems not improbable, this should turn out to be the most far-reaching discovery of the century, the historian of the future will be rather puzzled to explain why, among scores of names and observations, not one name, not one observation has been contributed by the nation which boasts itself the best educated, the most progressive and enlightened of all. The tribute of America is conspicuous by its absence.

But slight significance could lie in such a detail of the facts were the cases exceptional. In sketching out this none too flattering picture, I have picked the instances merely as they have occurred to me; not for the purposes of an indictment. Take an instance or two more.

Within the last quarter of a century—that is, within a period during which the United States have been easily abreast of the other nations and tribes—an immense work has been done in trying to unravel the mechanism of the brain. We may never solve the mystery of thinking, conscious matter. But we are certainly in sight of a working theory as to how the substances in the myriad cells of the brain perform their work. The possibility of attaining to such an intimate knowledge of the mind dawned with the discovery by the Italian, Golgi, of new staining reactions. Fascinating to the last degree are the pictures of the brain revealed by the microscope, in the hands of a multitude of workers. The cosmopolitan character of science was never more admirably illustrated. The Spanish neurologist, Ramon y Cajal, vies with Bethe of Germany, Van Gehuchten of Belgium, Forel of Switzerland, Waldeyer of Austria. A whole library could be filled with monographs, memoirs, journals and great books on this single subject. Scarce any land beneath the sun is unrepresented, save America. In all this wealth of literature you search in vain for a reference to one American's work.

Another illustration takes us farther afield. Scarce any science has taken on so prodigious a development in later years as chemistry. As a science, it dates from Lavoisier, the French farmer of the taxes whose head fell in the Terror. The pivot of modern chemistry is the atom imagined by John Dalton, a learned Quaker of Manchester, whose book appeared in 1808. So vast a field does this science now cover that hardly any man is master of more than a part. A German chemical dictionary, Beilstein's, dealing with but a single branch, organic chemistry, treats of 50,000 distinct compounds. There are half a dozen other important branches, each with its own huge literature—with special journals, even. It is almost a world by itself. Primacy here has shifted about from one country to another throughout the century, and chiefs and leaders have come from every point of the compass. Obscure lands, like Sweden, Norway, Russia, have been often at the fore. Yet the history of this wonderful science could be written in full detail without mention of perhaps more than a single American name. It will better indicate the state of the work in this country to note that the work of this single American, Professor Willard Gibbs, was unrecognized, was unknown, until it had been dug from the Connecticut archives by a Dutch chemist, after it had lain buried for nearly twenty years.

Perhaps in the minds of some, obsessed with the notion that a new country necessarily means a new people, and that the gentler nurture of the intelligence which we call the sciences and the arts had small show in America until recent years, it will be judged that I have had here under view a time too long. It will not be difficult to find a science that belongs wholly to recent years, where, therefore, our own country has had an equal chance with any other. Take a special province of chemistry that has become of great commercial importance within a very few years: Electrochemistry.

Whatever scattered processes might have existed prior to 1885, the science itself was then a thin and meagre affair. All that was known might have been acquired in an hour or two of close application. Though Clausius in Germany and Williamson in England made tentative efforts at a consistent scientific theory about the middle of the century, the discoveries of Faraday in the thirties represented the sole progress from the conceptions of Grotthaus, which date from 1805, and are still to be found in many American text-books in current use. The moot question was one that had the greatest importance to chemistry in general and particularly to the chemical explanation of life-processes: What happens when a substance is dissolved in water or other liquid?

Almost every one knows that pure water does not conduct electricity. The end of a wire circuit, dipped in the water, lets through no current. A lump of table salt or a spoonful of sulphuric acid not merely makes the water a conductor but gives rise of itself to an electric current. This was the essence of the discoveries of Galvani and Volta. A lump of sugar, so dissolved, has no such effect.

The explanation of these phenomena, and the practical founding of a new science as well, was the joint work of Van't Hoff, a Dutchman; Arrhenius, a Swede; Ostwald, a Polish German; Raoult, a Frenchman. Extended by eager investigators in every direction, the new theories have worked a genuine revolution in chemistry itself; they have given rise to a number of new industries, which, if we add to them the aluminium and calcium carbide industries, born of the electric furnace, are already worth millions of dollars to America alone; millions more to Europe. The new theories, moreover, seem to throw a flood of light on the most puzzling problems of life. Thanks to them, we are on the way now to a connected account of all vital actions, whether of digestion or reproduction, growth or death, on a simple mechanical or chemical basis. Our bodies and our brains consist very largely of water; the blood carries in solution all the materials which maintain life, so that if we have a complete theory of solutions, we shall have a complete theory of life. We may be able to answer without embarrassment the old, old question, What is life?

The astonishing development of this province of knowledge, within a space of time so brief, a development thoroughly international in character, is a striking example of that admirable organization of modern society which permits a degree of cooperation and an ease of communication, coupled with the stimulus of friendly rivalry, which would have been impossible a few centuries ago. Nowhere is this splendid solidarity, this intelligent "community of interest" so much in evidence as in this especial field; nowhere is the remarkable isolation of the United States from the rest of the scientific world more clearly illustrated. A list which would include the names of even the lesser builders of this imposing fabric would hardly include that of one American.

It would be easy to multiply examples. Here is the far-reaching theory of the ether, explaining or at least offering the only existing explanation of the phenomena of light, heat, electricity and magnetism, of the Marconi telegraph and X-ray photography. Whether it stand, or whether a simpler and better theory shall replace it later, it is assuredly the most brilliant example we possess of the fruitful union of scientific experiment and the scientific imagination. Wise men from among many peoples have come bearing their gifts; but, in the long line from Kelvin and Helmholtz to Lorenz and Poincaré, you discover no faces out of the desert of the western continent.

It is pretty much the same story wherever we turn. What is the cause? Why is it that this people, now marching to the industrial conquest of the earth, has done so little, comparatively, in the realms of science? I leave the answer to others who may love large generalizations more. My purpose was rather to indicate a condition than to propose a remedy. It is certain we do not lack for colleges and institutions of "higher culture." The sums which our Croesuses scatter with lavish hand are the wonderment of Europe. We are a clever people, undoubtedly; this we have no need to be told; our newspapers and orators do not miss an opportunity of telling us so. We have done big things; and it is, perhaps, just for that reason, just because of the rich prizes of business, that the Faradays and Claude Bernards are not to be found among us.

A few weeks ago France did honor to one of the century's notable men, her great chemist, M. Berthelot. The President of the Republic was there to preside; it was a national affair. I suppose M. Berthelot may be accounted the greatest experimental genius since Faraday; the list of his discoveries, the range of his work, the fertility of his resources have been amazing; and it is the boast of his countrymen that he never took out a patent. One of his eulogists said that his work had been done for mankind. He has long been a Senator of France; he was for a time

Minister of Foreign Affairs; yet it is told of him that visitors in winter are invited to his bedroom when they call, a fire there meaning a slight economy of coals! It is a little difficult to assimilate such a character to American ideas of success, yet even our Midases may feel dimly the greatness of such simplicity as that.

The life of M. Berthelot recalls that of Pasteur, or again that of the great physiologist, Claude Bernard. They, like Faraday, might each have had millions; they declined prizes that it needed but a lifted hand to grasp. They labored for the race, and perhaps some day we shall come to honor them as much as we now instinctively honor a slayer of men or a millionaire. The work of Berthelot, like that of Bernard, has been done chiefly at the College de France; that of Faraday was done at the Royal Institution of London. Every one knows of the Pasteur Institute, though not many know how widely its activity has been extended and the multitude of novel things done there in recent years.

We lack in America anything just like these three institutions, as we lack anything like the German University system, which gives German professors so wide a latitude of time for original experimental work. It may be that one cause of our inferiority in a scientific way lies in this want.

Each of these celebrated seats has a history that is unique. The Pasteur Institute was founded as a national memorial to the illustrious man whose name it bears. That restless, tireless genius had saved France millions of treasure and thousands of lives. The silk industry, the wine industry, medicine, surgery, the dairy, stock raising, the most intimate sources of national wealth, well-being and happiness even, had felt the impress of his mighty hand. Scorning the rich rewards which might have been his, had he chosen to put his discoveries under the seal of letters patent, Pasteur deserved well of his people. They understood it; they honored him, as few men of science have ever been honored while they were alive. But medals and decorations did not suffice. So, when one of the great newspapers opened a subscription for a splendid memorial, for an institution wherein Pasteur and his disciples might carry on their work under the most favorable conditions, the response was instantaneous and touching. There was hardly a humble home in France which was not, in some way, indebted to Pasteur, and there was hardly a humble home in France from which a slender subscription did not come. The Institute was the result.

Thanks to the munificence of the Baroness Hirsch, a new building has been recently completed, devoted wholly to biological chemistry and doubling the capacity of the institution. Workers come there now from every part of the earth. Show that you have a work to do, and all the resources of the most perfectly equipped laboratory, all the aids of modern technical and scientific instruments—grown exceeding complicated now and expensive—are at your disposal.

It would be strange if such an institution did not yield rich fruit, and under the guidance of the present Director, M. Duclaux, aided by men of splendid talent, like Roux, Chamberlain, Metchnikoff, Gabriel Bertrand, Mazé and many others, a great work is being done. The whole theory of fermentation, and the wide rôle of the various ferments in every phase of animal and vegetable life, as well as in many industries, is being worked out. So far do its labors extend that very recently, under Metchnikoff and his especial aids, the senility of the cells and the causes of old age are being investigated. Perhaps we may look forward to the day when we shall find agents able to counteract the growing years. Science has many dreams, and the everlasting fountain of Ponce de Leon is assuredly one.

The main body of the work of the Pasteur Institute has now grown too severely technical to admit of brief description; it is enough to say that nowhere else, perhaps, has so close an approach been made to the solution of the most intimate problems of hygiene, of health and of life.

Is it needful to add that we have no institution in America comparable to the Pasteur Institute, no great working laboratory where the investigator may go with his hopes and his plans, and work upon them advantageously and in peace?

France has yet another institution of a slightly different character, yet contributing to the same end, the unimpeded pursuit of experimental science. That is the College de France. Founded in the days of the splendor, and originally devoted chiefly to theology and philosophy, it has within the century taken on more and more the stamp of a research institution. There the work of Magendie and his great pupil, Claude Bernard, was done. There Renan sat and taught. There M. Berthelot has pursued uninterruptedly his fertile and fruitful career. Each of its professors is expected to give, once or twice a year, a series of lectures; and these have come to be more and more a summing up and synthesis of the most recent work in each especial field. These lectures are free to all; you may go or stay, or drop in now and then as your leisure and inclination decree. There are no entrance examinations, no fees to pay. If you care to enroll yourself regularly and attend a given number of series, a diploma is at your disposal. Whether you take it or no, a liberal education is yours for the asking, or rather for the attending. Within the wide leisure of these classic halls you may gather the latest results from every domain of human knowledge.

The labor of the series of lectures entails no great drain upon the time of the occupants of the various chairs; it serves rather as an excellent drill and as an incentive to clear popular exposition of special studies. For the rest, the professors are free to pursue their tasks and their dreams, with never an account to give either to the public or to the state. Is it any wonder that under such a system some of the finest research of the century has been done there? Scarce any single institution of the world can show so proud a roll of memorable names and of achievements that mark an epoch. If there is anything in America which may be likened to the College de France, it is, perhaps, the Smithsonian Institution at Washington. Much notable work has been done there; America has no more distinguished *savant* than its secretary, Professor Langley; and yet it would be admittedly unfair to compare for a moment the work of the two. The Smithsonian has no such resources, no such equipment, and, it may be added, no such far-reaching aims.

It is to be noted in passing that almost all of the courses of the chief university of France, the Sorbonne, are equally open to the public, with neither formality nor price. There, for the trouble of entering its walls, at almost any time you may hear the chief luminaries of French science and French letters; you may listen to the elegant periods of M. Faguet, or, under the grace of M. Moisson's facile discourse, feel the most recondite subjects take on the allures of romance. So far as I know, this is true of no American university.

Paris has yet a fourth institution very close of kin to the Pasteur and the College. A couple of miles to the east of the

University stands the old Jardin des Plantes, made famous by the genius of Cuvier. There a large number of professorships, touching all the various departments of scientific instruction, are set aside for original minds who seem to have a work in the scientific world to do. They are "blue ribbon" posts, and afford independence, leisure and stimulus for that patient, unremitting, undiscouraged toil which is at once the condition and the source of the best scientific work. There Professor Becquerel made his astonishing discoveries of substances which give off light and energy without apparent drain, inexhaustible and unceasing, seeming even to contradict the fundamental law of natural phenomena, the conservation of energy. There Maquenne was the first to produce calcium carbide, from which comes acetylene and a new industry; there he now pursues his work upon the chemistry and constitution of the sugars. I cite only two names from a score or more.

Without naming the École Normale, where St. Claire Deville spent his active life, or the School of Arts and Manufactures, or the College of Pharmacy, where both Berthelot and Moisson gained their reputations, nor a number of other minor institutions, here are three great seats of learning, chiefly devoted to experiment and research. This in a single city! Need there be any marvel that France should possess a roll of great names so resounding that, as I have indicated, the comparatively meagre roll which the United States may produce seems inconsiderable indeed?

London has a similarly admirable example to offer. The amount of genuinely scientific work which England has done, from the days of Boyle and Hooke and Newton, has been noteworthy enough in itself; it has been astonishing, when the singular indifference to science alike of the English Universities and of the English people themselves, taken broadly, is considered. Although it was at Oxford that Sir Robert Boyle laid the foundations of chemistry, the contributions of the old English university to the advancement of knowledge have been humiliatingly small. Cambridge, within the last forty years, has done a very distinguished work; and the same may be said of the Scotch universities.

But the stronghold of English science within the last century has distinctly been the Royal Institution in Albemarle Street.

From thence have the most brilliant discoveries in England come. There the singularly varied mind of Dr. Thomas Young elaborated the undulatory theory of light, and deciphered the hieroglyphs from the tombs of the Ptolemies. There the flashing genius of Sir Humphry Davy devised the first electric light, and set the man in the street talking of the latest marvels of chemistry. There the whole life work of Faraday was done. There the picturesque imagination of Tyndall made the hardest subjects of physics as fascinating as a tale of Cathay. There Professor Dewar and Lord Rayleigh have made their striking discoveries of new elements, and opened up new realms for investigation.

The Royal Institution was founded by an American. Benjamin Thompson, later Count Rumford, was born in one of the villages near Boston. His precocious genius and dominating ways aroused enmity against him; and when the war of the Revolution broke out and he started to raise a company of militia, he was literally driven over to the British side. He fled to England to become, at twenty-four, Under-Secretary of State, and at twenty-seven a member of the Royal Society. Knighted, his restless love of adventure took him to the Continent, drifting toward one of the eastern wars. Entering the service of the King of Bavaria, he was made Count Rumford for his genius as an administrator. He was virtually prime minister; and, for a time, when the King had fled, it was he who ruled. In a single day, he banished mendicity from the most beggar-ridden nation in Europe. When he returned to England, just a century ago, he conceived the plan of a great institution whose chief object should be the diffusion of knowledge and of the benefits of science among the people.

The result was the Royal Institution. It has scarcely held to the ideals of its founder. Its chief features are its courses of lectures. Each year, the most notable men of England and the Continent are drawn upon to sketch in an entertaining way the latest steps of the sciences. Travellers and inventors come, too; there are courses for young folk; there is a splendid library, and no club in London is more inviting. The membership fee is £10 a year, and the list is large. No wonder, for a tolerably assiduous attendance affords an opportunity to listen to and to make the acquaintance of the most famous and most interesting men of the time.

There are but three professorships. Like those of the College de France, their duties are light and the opportunities for research are wide. The system is ideal; yet, considering the number of chairs, it is simply a marvel that a single institution in a single century could show such a roster of great names, such an array of genuine achievements. It would be hardly too much to say that, during this hundred years of its existence, the Royal Institution alone has done more for English science than all of the English universities put together. This is certainly true with regard to British industry, for it was here that the discoveries of Faraday were made.

The German university system and the independence and leisure which it affords German professors is too well known to need sketching here. It is pleasing to note that something of this same spirit and of this same system is coming into vogue with our American universities. Of this, much good may come. But there is room—nay, if the United States wish to hold the same position in the world of science as they are so proud to hold industrially, commercially and perhaps in a social and literary way as well, there is a very articulate need, for institutions like those of Paris, and like the Royal Institution which an American refugee founded, with such large results, in London.

It would require but the co-operation of those who are broadly interested in scientific progress, and who have a desire to keep abreast of the swiftly advancing knowledge of their day, to achieve the beginnings of a great institution which should be at once a scientific club, a forum where the chief notables alike of Europe and America might be gathered and heard, and a seat of scientific research. I should like to see, I should like to assist in, the founding of such an institution in the chief city of the New World.

CARL SNYDER.